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REACTION TUBE COOLING METHOD
[HANNO NO REIKYAKUHOHO]

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Specification

1. Title of the Invention

Reaction Tube Cooling Method

2. Scope of Patent Claims

A reaction tube cooling method that feeds a coolant into an outer tube (6) of a reaction tube having a double-tube structure with said outer tube (6) formed around inner tube (1) to cool off the wall of said inner tube (1) by said coolant, characterized by the following facts:

The coolant (11) fed into said outer tube (6) is converted into fine grains (11A) beforehand; the fine grains are blended and dispersed in a carrier gas and are fed into said outer tube (6); the wall of said inner wall (1) is cooled off with the aid of the vaporization heat generated when the fine grains are vaporized.

3. Detailed Description of the Invention

(Summary)

The present invention pertains to a reaction tube cooling method used for a vapor-phase epitaxial growth apparatus, or the like.

The objective is to lower the pressure of the coolant used for cooling the reaction tube, reduce the flow rate of the coolant, and miniaturize the reaction tube.

In the reaction tube cooling method that feeds a coolant into the outer tube of a reaction tube having a double-tube structure with the outer tube formed around an inner tube to cool off the wall of the inner tube by the coolant, the coolant fed into the outer tube is converted into fine grains beforehand. The fine grains are blended and dispersed in a carrier gas and are fed into the outer tube. The wall of said inner tube is cooled off by the vaporization heat generated with the aid of the fine grains are vaporized.

(Industrial Application Field)

The present invention pertains to a reaction tube used for a vapor-phase epitaxial growth apparatus, or the like.

A compound semiconductor crystal of mercury cadmium telluride ($Hg_{1-x}Cd_xTe$) having a narrow energy band gap is used as a material for forming the IR detection element.

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In the case of forming the crystal of the aforementioned mercury cadmium telluride ($Hg_{1-x}Cd_xTe$), the crystal of CdTe with good crystallinity is epitaxially grown on a cadmium telluride (CdTe) substrate, followed by epitaxially growing the crystal of $Hg_{1-x}Cd_xTe$ thereon.

(Prior Art)

In the case of epitaxially growing the crystal of CdTe, as shown in Figure 3, the CdTe substrate 3 is set on a susceptor 2

made of carbon in the inner tube 1. After the inner tube is extracted to a vacuum degree of about 10^{-4} Torr, hydrogen gas used as the carrier gas, dimethyl cadmium [$(CH_3)_2Cd$)] is carried in the hydrogen gas, and diethyl telluride [$(C_2H_5)_2Te$] gas or another gas for epitaxial growth is fed into the inner tube 1 from a gas feeding pipe 4.

The substrate 3 is heated when the susceptor 2 is heated as a high-frequency power is applied to a high-frequency induction coil 5 provided around the inner tube 1. The gas for epitaxial growth fed into the inner tube 1 is decomposed on a heated substrate 3. The decomposed component of the epitaxial growth gas is attached to the substrate to epitaxially grow the crystal of CdTe.

However, the wall of the inner tube 1 is heated by the heating of the susceptor 2. As a result, the gas for epitaxial growth fed into the inner tube 1 is decomposed on the heated tube wall before it reaches the substrate 3. The decomposed component is attached to the tube wall. As a result, a prescribed amount of gas for epitaxial growth is not supplied to the substrate 3.

Then, the decomposition product attached to the wall of the inner tube 1 falls onto the substrate due to the gas fed into the inner tube to cause crystal defects of the epitaxial growth grown on the substrate.

Therefore, a reaction tube 7 having a double-tube structure with an outer tube 6 provided to cover the periphery of the inner tube 1 is provided on the gas entrance side of the inner tube 1. Cooling water is fed into outer tube 6 to cool off the wall of the inner tube 1 so that the decomposition product of the epitaxial growth gas is not attached to the wall of the inner tube.

The reaction tube 7 for epitaxial growth is formed by the double tube structure comprised of the inner tube and the outer tube.

(Problems to be Solved by the Invention)

The cooling water is fed into the outer tube 6 at a flow rate of 20 L/min while the water pressure kept at 2 Kg/cm^2. However, when such a large amount of water is fed under high pressure into the outer tube 6, it is necessary to manufacture a reaction tube having an outer tube with sufficiently high strength against the water pressure. This makes production of the reaction tube difficult.

Also, the volume of the outer tube is increased in order to receive the large amount of cooling water. As a result, the diameter of the inner tube 1 is increased, and thus the size of the entire epitaxial growth apparatus is increased.

The objective of the present invention is to solve the aforementioned problem by providing a method for cooling off the

reaction tube for epitaxial growth, which can reduce the flow rate of the coolant and reduce the volume of the outer tube of the reaction tube, that is, the volume of the reaction tube.

(Means for Solving the Problem)

In order to realize the aforementioned objective, the present invention provides a reaction tube cooling method characterized by the following facts: the coolant fed into the outer tube is converted into fine grains beforehand; the fine grains are blended and dispersed in a carrier gas and are fed into the outer tube; the wall of said inner wall is cooled off by the vaporization heat generated with the aid of the fine grains that are vaporized.

(Operation)

When water used as coolant is vibrated by an ultrasonic vibrator, fine grains of the water droplets are formed on the water surface. Also, fine grains of water droplets are formed when steam is heat insulated and swollen. When the fine grains are blended and dispersed in nitrogen gas, or another carrier gas, and are fed into the outer tube, as the fine grains of the water droplets are vaporized, the vaporization heat is deprived from the heated part of the inner tube wall. Therefore, the temperature of the tube wall can be easily lowered by the carrier gas containing the dispersed fine grains without using a large amount of water. Consequently, there is no need to

manufacture a reaction tube that is difficult to produce because of the strength needed against the high water pressure. Also, since there is no need to feed water in such a large amount,

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the reaction tube with an outer tube having a large volume becomes unnecessary.

(Application Example)

In the following, an application example of the present invention will be described in more detail with reference to the figures.

Figure 1 is a diagram describing the reaction tube cooling method disclosed in the present invention. As shown in this figure, an ultrasonic vibrator 13 is provided on the bottom of a container 12 containing water 11. As a result of the vibration of the ultrasonic vibrator 12, the water in the container becomes fine grains of small droplets having a diameter of about 0.1 μm and flies out.

The fine grains of water float in the space above the container 12 and are dispersed in the carrier gas composed of nitrogen gas fed from a gas feeding pipe 14 that is connected to the outer tube 6 of the reaction tube 7. The dispersed water droplets 11A in the form of fine grains are fed into the outer tube 6 along with the nitrogen gas. As far as the amount of the fine grains is concerned, 0.1 g of water is converted into fine

grains of about 0.1 μm when the flow rate of the nitrogen gas is 2 L/min.

In this way, the temperature of the wall 1A of the inner tube 1, which used to be 250°C in the conventional method, can be lowered to 180°C. The wall of the inner wall can be cooled off effectively.

In the second application example, as shown in Figure 2, the container 21 that contains water, a piston 22 that moves up/down in the container 21, and a shutter 23 that is accommodated in the container 21 and can open/close with respect to the gas feeding pipe 14 connected to said outer tube 6 are made of a heat insulating material. After the piston 22 is pressed down and steam 25 is fed into the container 21 from the steam supply port 24 of the container 21, the piston 22 is lifted to pressurize the steam in the container 21. Then, the shutter 23 is open to form fine grains of water droplets by means of heat-insulating swelling. The formed fine grains are dispersed in the carrier gas of the gas feeding pipe 14.

It is also possible to convert the steam into the fine grains of water droplets by lifting said piston 22 and then pressing down the piston 22 to form the fine grains of water droplets by means of heat-insulating swelling, followed by opening the shutter 23.

As the third application example, although it is not shown in the figure, it is also possible to form the mist-like water fine grains by using a spraying apparatus and then dispersing the fine grains in a carrier gas.

As described above, according to the method of the present invention, there is no need to feed cooling water in such a large amount as in the conventional method. Also, there is no need to apply high pressure as in the conventional method to the outer tube into which the coolant is fed. Therefore, the reaction tube can be easily produced in a smaller size.

Instead of water, it is also possible to use a chemically inactive coolant with high vaporization heat. An example is Flourinert (product name, produced by Dupont 3M Co., Ltd.).

The method of the present invention can be applied not only to the reaction tube for epitaxial growth but any reaction tube that requires cooling, such as the reaction tube for diffusion.

(Effect of the Invention)

As described above, according to the method of the present invention, there is no need to feed cooling water in a large amount. Also, there is no need to apply high pressure as in the conventional method to the outer tube into which the cooling water is fed. Therefore, the reaction tube can easily be produced in a small size. When such a reaction tube is used to

form an epitaxial growth apparatus, a small and compact epitaxial growth apparatus can be obtained.

4. Brief Description of the Figures

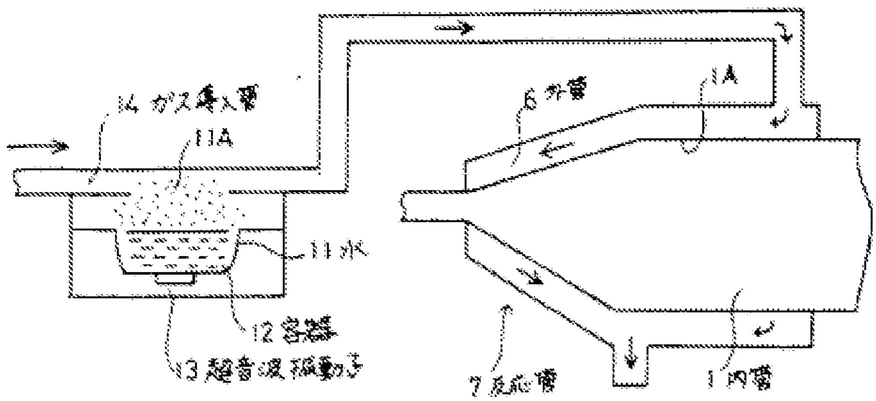
Figure 1 is a diagram describing the first application example of the present invention.

Figure 2 is a diagram describing the main parts in the second application example of the present invention.

Figure 3 is a diagram describing a conventional vapor-phase epitaxial growth apparatus.

In the figures,

1 represents the inner tube, 1A represents the tube wall, 6 represents the outer tube, 7 represents the reaction tube, 11 represents water, 11A represents the droplets, 12, 21 represent the container, 13 represents the ultrasonic vibrator, 14 represents the gas feeding pipe, 22 represents the piston, 23 represents the shutter, 24 represents the steam supply port, 25 represents the steam.



本発明のオ1実施例の説明図

第 1 図

Diagram Describing the First Application Example of the Present Invention

Figure 1

1 Inner Tube

6 Outer Tube

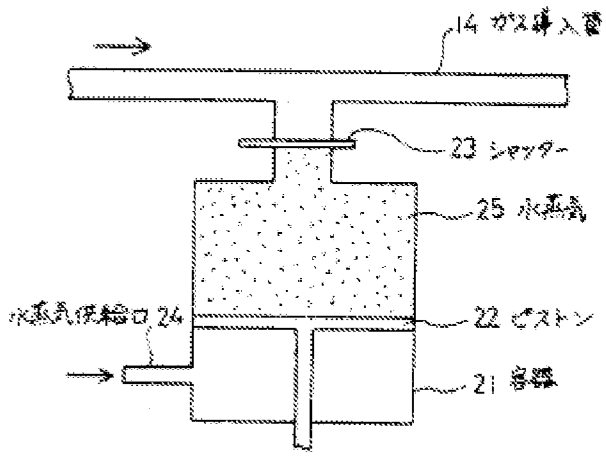
7 Reaction Tube

11 Water

12 Container

13 Ultrasonic Vibrator

14 Gas Feeding Pipe



本発明の第2実施例の要部の説明図
第 2 図

Diagram Describing the Main Parts in the Second Application Example of the Present Invention

Figure 2

14 Gas Feeding Pipe

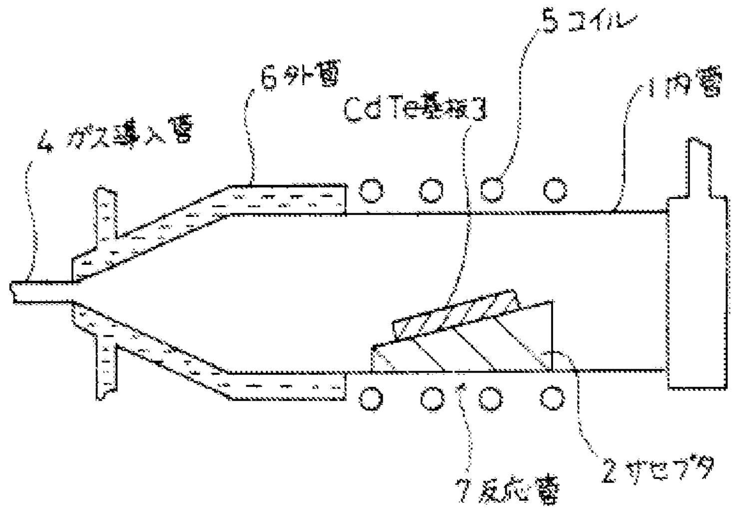
21 Container

22 Piston

23 Shutter

24 Steam Supply Port

25 Steam



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第 3 図

Diagram Describing A Conventional Vapor-Phase Epitaxial Growth Apparatus

Figure 3

1 Inner Tube

2 Susceptor

3 Cdte Substrate

4 Gas Feeding Pipe

5 Coil

6 Outer Tube

7 Reaction Tube